*Journal of Science and Science Education*
Vol. 2 No. 1 May 2018 21–28
ISSN: 2598-3830 (Online)

# Applying venn diagram to present bloom's cognitive level of students of a physics learning about light refraction using developed independent lab work module and PhET simulation "bending light"

**Nurul H. Astuti, Debora N. Sudjito*, Diane Noviandini**

*Department of Physics Education, Faculty of Science and Mathematics,*
*Universitas Kristen Satya Wacana*
*Jl. Diponegoro 52–60, Salatiga 50711, Jawa Tengah, Indonesia*

## ABSTRACT

Evaluation shows the effectiveness of teaching and learning of a class. Mostly teachers provide evaluation in low cognitive level so students are able to achieve the minimum passing grade. Whereas a good evaluation should use Bloom's Taxonomy as a basis for classifying student's cognitive level. It leads teacher to provide a learning that facilitates student's achievement of high cognitive level, including using independent lab work module. Teachers also typically provide a global report evaluation, i.e. providing the final score only, without presenting the distribution of students' cognitive level. For this purpose, Venn Diagram is used to show the distribution of students' cognitive level based on Bloom Taxonomy. This research aimed to present the distribution of students' Bloom cognitive level using Venn Diagram and to investigate whether the development of independent lab work module about light refraction using PhET simulation "Bending Light" can make students achieve the cognitive levels of knowing, understanding, applying, and analyzing. The obtained data was analyzed using qualitative descriptive method. The respondents were 17 freshmen of Physics Education and Physics Students of UKSW Batch 2016. The post-test showed that all students achieved higher cognitive levels. Thus, the developed independent lab work module was able to improve students' cognitive level. Venn Diagram could also simplify the presentation of the distribution of students' Bloom cognitive level for teachers.

**Keywords** : bloom's cognitive level, light refraction, venn diagram

**Received:** September 28, 2017; **Accepted:** May 28, 2018; **Published online:** July 18, 2018
*Corresponding author: debora.natalia@staff.uksw.edu

**Citation:** Astuti, N. H., Sudjito, D. N., & Noviandini, D. (2018). Using venn diagram to present bloom cognitive levels of students of a physics learning about light refraction developed independent lab work module and PhET simulation "Bending Light". *Journal of Science and Science Education*, *2*(1), 21–28.

## 1. Introduction



Learning evaluation provides learning feedback for students and teachers in order to know the effectiveness of learning in the classroom. In fact, generally the results of physics learning evaluation is lower than other subjects, both for high school and college levels Azar (2005). It often causes teachers make lower cognitive levels of evaluation in order to let all students achieves good grades and beyond the Minimum Criteria for Completion, although the evaluation process should have been based on taxonomy as a standard of the problems so that the actual learning success can be observed Sutiadi & Kurniawati (2015).

Other thing is that generally teachers provide global evaluation report, i.e, presenting the final scores only, without the cognitive level of students Maghfiroh et al. (2013), as well as in the evaluation questions. In order for teachers and students to know the extent of the cognitive level that has been achieved by students in learning, it is necessary to find a way of presenting the evaluation of learning that can show the cognitive level of students. Astuti (2016) made a research about an instrument to presenting Bloom's cognitive levels of students after taking an evaluation so that the distribution of students' cognitive level achievement in a class is easier to be read and analyzed. Venn Diagrams can provide a clear picture for teachers and students about students' cognitive levels achievement in teaching and learning activities.

Consequently, learning that can facilitate students in increasing their cognitive abilities to higher levels and achieving learning indicators is needed. Such a learning might not only be presented in the form of class meeting Rosmalinda et al. (2013), but also by independent lab activities. Students can learn and find a concept through lab activities out of the regular class meetings. Students do a series of scientific activities known as the science process skills to solve the problems during the lab activites. According to Rezka (2007), scientific process skills consist of basic skills and integrated skills. In addition, physics learning should make students think critically and develop cognitive thinking skills Agustihana (2015). Stages or levels of thinking (cognitive) of students have been presented in Bloom's Taxonomy. Based on Blooms Taxonomy, the cognitive domain consists of six levels of the cognitive differences, i.e. remembering, understanding, applying, analyzing, evaluating, and creating (Clark, 2015; Atherton, 2013). Therefore, Bloom Taxonomy is used as the basis for the learning indicators and learning evaluation.

Lab activities (practicum) usually done in the laboratory, but it is often constrained by the limited available laboratory equipments to the number of students, the limited time of laboratory using, and the risk of laboratory equipments' damage. This can be solved by using the animations or simulations. Recently there are many applications or animations are created to simulate the lab activities. With those simulations, many problems can be solved. Simulations can be used anywhere, anytime, and repeatedly (Wijaya, 2017). One of the physics simulations can be used is PhET (Physics Education Technology) (Perkins et al., 2006). Dinavalentine (2016) has made an independent lab work module about light refraction using PhET simulation "Bending Light". From her research, it is concluded that the independent lab work module of light refraction using PhET simulation "Bending Light" can help students to understand light refraction deeper and easier by doing independent lab work out of class meeting.

The independent lab work module about light refraction using PhET simulation "Bending Light" created by Dinavalentine (2016) only covers the cognitive levels of knowing and understanding (Dinavalentine, 2016). Therefore, in this study, the independent lab work module development about light refraction using the PhET "Bending Light" simulation is developed to cover the cognitive levels of applying and analyzing. This development is made in order to investigate its effectiveness on making students achieve higher cognitive levels.

This research aimed to present the distribution of students' Bloom cognitive levels using Venn Diagram and to investigate whether the development of independent lab work module about light refraction using PhET simulation "Bending Light" can make students achieve the cognitive levels of knowing, understanding, applying, and analyzing. The benefits of this research are to provide such a way of presenting information and analyzing students' cognitive levels by using Venn Diagram based on the evaluation result.

## 2. Materials and Methods

### *2.1 Bloom's Taxonomy and Venn Diagram*

According to Bloom (1965), there are six levels of cognitive aspect ranging from the lowest : knowing (C1), understanding (C2), applicating (C3), analyzing (C4), synthesizing (C5), and evaluating (C6) (Atherton, 2013). Then Bloom's Taxonomy was revised becomes remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6) (Atherton, 2013). The cognitive aspect shows a sequence of thinking skills according to the intended purpose. The thinking process describes the thinking stage that must be mastered by students to be able to apply the theories into everyday life. The levels of cognitive aspect can be described in a pyramid form as shown in Figure 1. The first three levels (at the bottom of the pyramid) are the Lower Order Thinking Skills (LOTS), while the next three levels are Higher Order Thinking Skills (HOTS).


Figure 1. Bloom cognitive aspect pyramid.

In 1880, for the first time, John Venn who was an British mathematician introduced Venn Diagram to show the concept of set of theory in mathematics (Pirooznia, 2007). Venn Diagram is a diagram that present all possible logical relationships and hypothesis of a set of objects. The shape of the Venn Diagram is a rectangular box with some circles inside it. The circles represent the set and the rectangular box represents the universe of the set. The set is a collection of objects or objects that can be clearly defined and exist in one unity (have certain similarities), while the universe is a union containing the sets. From the Venn Diagram, the relationship between two or more sets or items or objects can be seen (Astuti et al., 2016).

The Venn Diagram can be used to present the distribution of students' cognitive levels (Astuti et al., 2016). The sets in the Venn Diagram can be grouped into sets of knowing (C1), understanding (C2), applying (C3), and analyzing (C4). The relationship is presented with a congruent overlapping region of the two or more circles called slice (Astuti et al., 2016). The distribution of Bloom cognitive levels in a class can be seen in the Venn diagram. If a student is in a particular circle (one circle), it means the student is at one cognitive level only. If a student is in a slice of two particular circles, it means the student achieves two cognitive levels. If a student is in a slice of three particular circles, it means the student achieves three cognitive levels. Furthermore, if a student is in a slice of four particular circles, it means the student achieves four cognitive levels : knowing (C1), understanding (C2), applying (C3), and analyzing (C4) – the highest achievement in this research (Astuti et al., 2016).

In order to present the distribution of Bloom cognitive levels of students to be analyzed easily, Venn Diagram is used to present it as shown at Figure 2. The focus of this study is the the slices ($\cap$) in the Venn Diagram that show the relationship of the four Bloom cognitive levels.

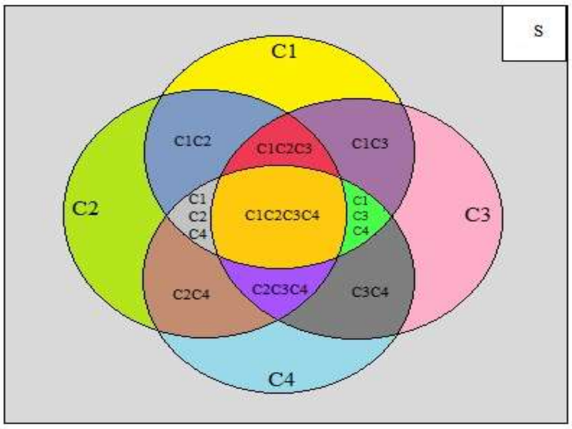


**Figure 2.** The venn diagram of four bloom cognitive levels.

### *2.2 Research Methods*

The descriptive research method was used in this study. The respondents of this study were 17 freshmen of Physics and Physics Education UKSW (Batch 2016). The independent lab work module about light refraction using PhET simulation of "Bending Light" made by Dinavalentine (2016) that was developed to four cognitive levels (knowing, understanding, applying, and analyzing), pre-test, post-test, observation sheets, and questionnaire were used as research instruments.

In this research, the learning objectives were determined first. Then the independent lab work module about light refraction using PhET simulation "Bending Light" made by Dinavalentine (2016) was developed from two cognitive levels (knowing and understanding) to four cognitive levels (knowing, understanding, applying, and analyzing) of Bloom Taxonomy. The pre-test, post-test, observation sheet, and questionnaire was made then.

Data gathering started by giving pre-test to the respondents. There were 20 multiple choice questions covering four targeted cognitive levels, i.e. the levels of knowing, understanding, applying, and analyzing. There were 5 questions of knowing (C1) cognitive level, 4 questions of understanding (C2) cognitive level, 5 questions of cognitive level applying (C3) cognitive level, and 6 questions of analyzing (C4) cognitive level. After that, the respondents did the independent lab work using PhET simulation "Bending Light" guided by the developed module out of class meeting. During the lab work, observer observed the students and filled out the observation sheet. Finally post-test and questionnaire were given to the students after the lab work done. The number of post-test questions was equal to the number of pre-test questions. Questionnaire was used to record students' responses to the developed independent lab work using PhET simulation "Bending Light" in helping them learnt light refraction.

The independent lab work module was used as a self-learning. The students were assigned to do many experiments using PhET simulation, then filled in every question was asked in it. The students run the simulation, collected and analyzed the data until they found the concepts about light refraction. There were guidance questions to ease students worked on independent lab work. In the consolidation section, there are questions of the dribblers used to analyze the experimental results and to draw conclusion. There were also problems that develop students' skills to apply the concepts of light refraction and to analyze a circumstance based on the concepts of light refraction. The independent learning using the module accommodated any criticism and suggestion from respondents for the further module improvement.

Each option in both the pre-test and the post-test questions was made in such a way to accommodate all possible answers to the students, so that when students work on the problem in the wrong way, any student will still get the answer to the available options in the questions. If the student did not have the correct concepts, the student would have difficulties in answering the problems.

All data obtained from the pre-test, post-test, observation sheet, and questionnaire were analyzed descriptively qualitatively. The pre-test result was used to see the distribution of students' cognitive level before the independent lab work done; while the post-test result was used to see it after the independent lab work done. The results of pre-test and post-test were presented in Venn Diagram for easier analysis of cognitive levels distribution.

## 3. Results and Discussion

In the independent lab work about light refraction using PhET simulation "Bending Light", there were 3 targeted learning objectives, i.e. (1) to explain Snell's Law for light refraction, (2) to investigate total internal reflection, and (3) to investigate the factors that affect the speed of light.

In this study, only the evaluation results are reported. The result of the pre-test given to the students before the independent lab work shown in Table 1 informs the initial distribution of students' cognitive level before the learning activities. The result of the post-test given to the students after the independent lab work shown in Table 2 informs the final distribution of students' cognitive level after the learning activities. In both Table 1 and Table 2, a student was grouped on a particular cognitive level if he can answer correctly at least 70% of questions of each cognitive level.

**Table 1.** Pre-test result.

| Cognitive Level | C1 | | C2 | | C3 | | C4 | | Bloom's Cognitive Level Achievement |
|---|---|---|---|---|---|---|---|---|---|
| Full Point (%) | 5 | 100% | 4 | 100% | 5 | 100% | 6 | 100% | |
| Student | | | | | | | | | |
| A | 2 | 40 | 2 | 50 | 1 | 20 | 1 | 17 | - |
| B | 1 | 20 | 2 | 50 | 1 | 20 | 1 | 17 | - |
| C | 2 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | - |
| D | 3 | 60 | 2 | 50 | 0 | 0 | 0 | 0 | - |
| E | 1 | 20 | 3 | 75 | 2 | 40 | 2 | 33 | C2 |
| F | 3 | 60 | 3 | 75 | 3 | 60 | 2 | 33 | C2 |
| G | 0 | 0 | 3 | 75 | 0 | 0 | 1 | 17 | C2 |
| H | 1 | 20 | 1 | 25 | 1 | 20 | 1 | 17 | - |
| I | 2 | 40 | 2 | 50 | 1 | 20 | 2 | 33 | - |
| J | 2 | 40 | 2 | 50 | 0 | 0 | 2 | 33 | - |
| K | 4 | 80 | 3 | 75 | 4 | 80 | 2 | 33 | C1+C2+C3 |
| L | 3 | 60 | 2 | 50 | 2 | 40 | 0 | 0 | - |
| M | 1 | 20 | 2 | 50 | 1 | 20 | 0 | 0 | - |
| N | 1 | 20 | 1 | 25 | 2 | 40 | 0 | 0 | - |
| O | 0 | 0 | 0 | 0 | 1 | 20 | 0 | 0 | - |
| P | 1 | 20 | 1 | 25 | 0 | 0 | 1 | 17 | - |
| Q | 1 | 20 | 1 | 25 | 0 | 0 | 0 | 0 | - |

**Table 2.** Post-test result.

| Cognitive Level | C1 | | C2 | | C3 | | C4 | | Bloom's Cognitive Level Achievement |
|---|---|---|---|---|---|---|---|---|---|
| Full Point (%) | 5 | 100% | 4 | 100% | 5 | 100% | 6 | 100% | |
| Student | | | | | | | | | |
| A | 5 | 100 | 4 | 100 | 5 | 100 | 0 | 0 | C1+C2+C3 |
| B | 5 | 100 | 4 | 100 | 5 | 100 | 0 | 0 | C1+C2+C3 |
| C | 5 | 100 | 4 | 100 | 3 | 60 | 4 | 67 | C1+C2 |
| D | 5 | 100 | 4 | 100 | 4 | 80 | 3 | 50 | C1+C2+C3 |
| E | 4 | 80 | 3 | 75 | 5 | 100 | 5 | 83 | C1+C2+C3+C4 |
| F | 5 | 100 | 3 | 75 | 4 | 80 | 5 | 83 | C1+C2+C3+C4 |
| G | 5 | 100 | 4 | 100 | 5 | 100 | 0 | 0 | C1+C2+C3 |
| H | 5 | 100 | 3 | 75 | 2 | 40 | 4 | 67 | C1+C2 |
| I | 5 | 100 | 4 | 100 | 2 | 40 | 5 | 83 | C1+C2+C4 |
| J | 5 | 100 | 4 | 100 | 3 | 60 | 4 | 67 | C1+C2 |
| K | 5 | 100 | 3 | 75 | 4 | 80 | 5 | 83 | C1+C2+C3+C4 |
| L | 5 | 100 | 4 | 100 | 3 | 60 | 4 | 67 | C1+C2 |
| M | 5 | 100 | 2 | 50 | 3 | 60 | 4 | 67 | C1 |
| N | 5 | 100 | 4 | 100 | 3 | 60 | 2 | 33 | C1+C2 |
| O | 5 | 100 | 4 | 100 | 0 | 0 | 0 | 0 | C1+C2 |
| P | 5 | 100 | 4 | 100 | 5 | 100 | 1 | 17 | C1+C2+C3 |
| Q | 5 | 100 | 1 | 25 | 4 | 80 | 4 | 67 | C1+C3 |

Based on Table 1 and Table 2, Venn Diagrams for the pre-test and post-test results are shown in Figure 3 and Figure 4, while the percentage distribution of Bloom cognitive levels of students before and after learning is shown in Figure 5 and Figure 6.

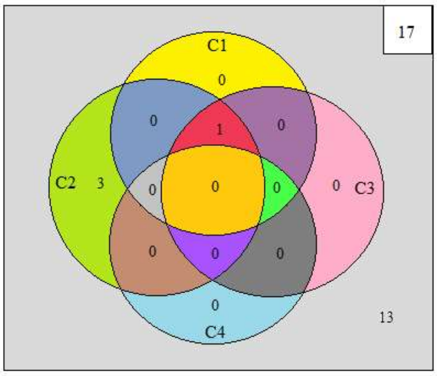


**Figure 3.** Venn Diagram of the pre-test result presents the distribution of students' cognitive level before learning activity.

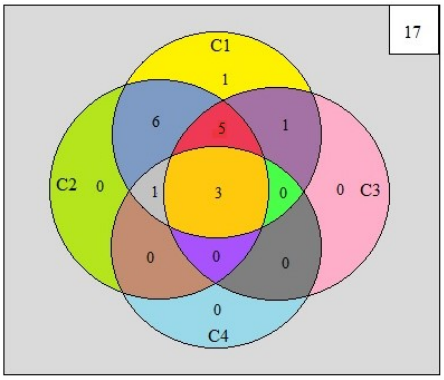


**Figure 4.** Venn Diagram of the post-test result presents the distribution of students' cognitive level after learning activity.

Based on the pre-test result from 17 respondents as shown in Figure 3 and Figure 5, initially before the independent lab work, there were only 3 students (17,7%) who were able to achieve cognitive level of understanding (C2) and 1 student (5,9%) who was able to achive cognitive levels of knowing, understanding, and applying (C1+C2+C3); while the other 13 students (76.4%) were out of the circles, meaning they were not able to reach any cognitive level yet. An interview with the students after pre-test shows that generally the students did not really understand the difference of light refraction and light reflection when those were applied in daily life. Mostly their incorrect answers told that they did not understand the concept of light refraction, the relationship between the angle of reflection and angle of refraction, the use of Snell's Law, and the concept of perfect reflection.

Thus, before the implementation of the independent lab work, there are only 4 students (23.6%) who are able to achieve Bloom's cognitive levels. An effective learning is needed to make students achieve higher cognitive levels.

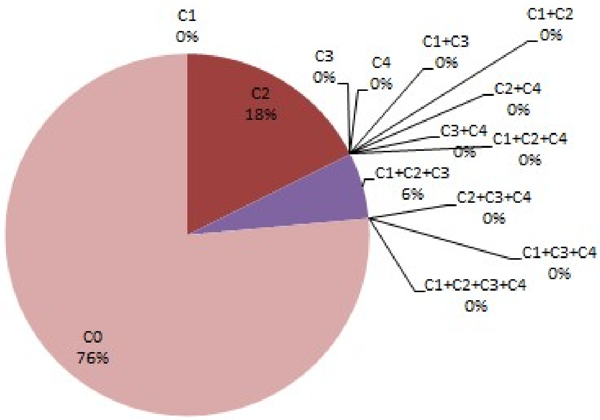


Figure 5. Pie diagram of percentage pre-test result.

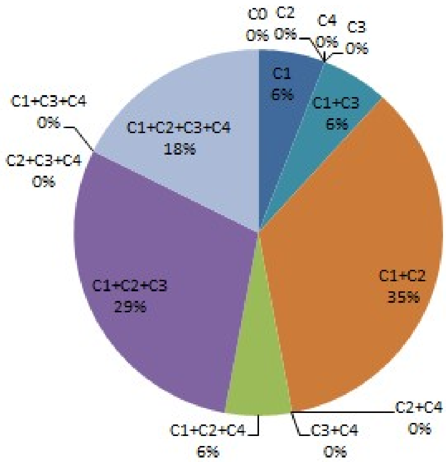


**Figure 6.** Pie diagram of percentage post-test result.

After conducting the independent lab work using simulation and module, students were given post-test questions. Based on the result of the post-test shown in Figure 4 and Figure 6, 3 out of 17 students (17,6%) were in middle slice; it shows that 3 students are able to achieve four cognitive levels. Initially two of them were only able to achieve the cognitive level of understanding (C2) and one was at the cognitive levels of knowing, understanding, and applying (C1+C2+C3). There was 1 student (5.9%) in the cognitive level of knowing (C1); he was previously out of the circles which means that he did not achieve any cognitive level yet. At the cognitive levels of knowing, understanding, and applying (C1+C2+C3), there were 5 students (29.4%); four of them were out of the circles and one of them was at cognitive level of understanding (C2). At the cognitive levels of knowing, understanding, and analyzing (C1+C2+C4), there was 1 student (5.9%) who was initially out of the circles. At the cognitive levels of knowing and understanding (C1+C2), there were 6 students (35.3%) who are initially out of the circles. At the cognitive levels of knowing and applying (C1+C3), there was 1 student (5.9%) who was initially out of the circles. There were no students at cognitive level of C2, C3, C4, C1+C3+C4, C2+C3+C4, C2+C4, and C3+C4. The post-test result informs that all students (100%) increase their cognitive levels and no student decreases his cognitive levels.

Figure 3 and Figure 4 shows clearly the distribution of Bloom cognitive levels of all students. It presents how many students located in each circle or each slice. It makes teachers or students easily seen the distribution of cognitive levels of all the class members. It means that Venn Diagram was effective to present the distribution of Bloom cognitive levels of students. Based on Figure 5 and Figure 6, students who initially did not achieve any cognitive levels, after the independent lab work could achieve particular cognitive levels. Students who previously achieve lower cognitive levels can finally achieve higher cognitive levels. It means that the developed independent lab work module was effective to help students improve their cognitive levels.

Furthermore, in the questionnaire, 89.8% of students said that they felt enthusiastic, interested, and assisted by the independent lab work module. The interview with some students also stated that they felt helped learning light refraction by the independent lab work module. Students felt involved directly, they found and solved problems that occured in everyday life but were still focused on the material discussed in the module, and the PheT simulations also made the students did not bore. This reinforces that the independent lab module effective to help students improve their cognitive levels.

## 4. Conclusion and Remarks

Based on the research, it can be concluded that the developed independent lab work module about refracting light using PhET simulation "Bending Light" is able to help students achieve higher cognitive levels. It can be seen and analyzed easily from the Venn Diagrams that presents the distribution of Bloom cognitive levels of students.

## References

Agustihana, S. (2015). Analisis peningkatam *higher order thinking skill* siswa Kelas XI SMAN 15 Surabaya dengan model pengajaran langsung dan kooperatif pada materi dinamika rotasi. *Jurnal Inovasi Pendidikan Fisika*, *4*(2), 124–128.

Astuti, M. P., Pattiserlihun, A., & Sudjito, D. N. (2016). Penggunaan diagram venn untuk analisa level kognitif mahasiswa berdasarkan taksonomi bloom pada *conceptual learning* tentang fluida dinamis. *Prosiding Seminar Nasional Quantum* (pp. 398–391). Yogyakarta: Program Studi Pendidikan Fisika, Universitas Ahmad Dahlan.

Atherton, J. S. (2013). Learning and teaching; Bloom's Taxonomy. Retrieved from http://www.learningandteaching.info/learning/bloomtax.htm

Azar, A. (2005). Analysis of turkish high-school physics-examination questions and university entrance exams questions according to blooms' taxonomy. *Journal of Turkish Science Education*, *2*(2), 144–150.

Clark, D. (2015). Bloom's taxonomy of learning domains. Retrieved from http://www.nwlink.com/~donclark/hrd/bloom.html

Dinavalentine, M., Noviandini, D., & Sudjito, D. N. (2017). Desain modul praktikum mandiri tentang pembiasan cahaya menggunakan simulasi PhET bending light untuk mahasiswa (Unpublished graduate final assignment). Universitas Kristen Satya Wacana.

Maghfiroh, Q., Tapilouw, M., & Herrhyanto, N. (2013). Penerapan model pembelajaran konseptual interaktif (interactive conceptual instruction) untuk meningkatkan kemampuan pemahaman konsep matematis siswa SMP (penelitian eksperimen terhadap siswa kelas VII di SMP Negeri 29 Bandung). *Jurnal Online Pendidikan Matematika Kontemporer*, *1*(1).

Perkins, K., Adams, W., Dubson, M., Finkelstein, N., Reid, S., & Wieman, C. (2006). PhET: Interactive Simulation for Teaching and Learning Physics. *The Physics Teacher*, *44*, 18–23.

Pirooznia, M., Nagarajan, V., & Deng, Y. (2007). GeneVenn - A web application for camparing gene list using venn diagram. *Bioinformation*, *1*(10), 420–422.

Rosmalinda, D., Rusdi, M., & Hariyadi, B. (2013). Pengembangan modul praktikum kimia SMA berbasis PBL (*Problem Based Learning*). *Edu-Sains*, *2*(2), 1–7.

Sutiadi, A., & Kurniawati, R. (2015). Analisis butir soal ujian nasional SMA bidang fisika menggunakan taxonomy of introductory physics problem. Universitas Pendidikan Indonesia. *Prosiding Pertemuan Ilmiah XXIX HFI Jateng & DIY* (pp. 306–309). Yogyakarta: HFI Jateng & DIY.

Wijaya, M. S. (2017). Pengaruh praktikum virtual terhadap keterampilan berpikir kreatif siswa kelas X pada materi vertebrata (Unpublished graduate final assignment). Fakultas Tarbiyah Dan Keguruan, Institut Agama Islam Negeri Raden Intan Lampung.